

NOAA DATA REPORT ERL PMEL-

**CHEMICAL AND HYDROGRAPHIC MEASUREMENTS FROM THE EQUATORIAL
PACIFIC DURING BOREAL AUTUMN, 1992**

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REMOTE ACCESS TO DATA LISTED IN THIS REPORT

The data presented in this report is available on a computerized Remote Bulletin Board System (RBBS), Internet FTP and the World Wide Web (WWW). For information regarding electronic access to the data sets contact:

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Contoured sections of the data are also available at <http://www.pmel.noaa.gov/co2/eqpac.html>.

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Chemical and Hydrographic Measurements from the Equatorial Pacific during Boreal Autumn, 1992

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ABSTRACT. In the boreal autumn of 1992, NOAA's Climate and Global Change Program sponsored a major cooperative effort with the U.S. JGOFS Program in the central and eastern equatorial Pacific to investigate the unique role of equatorial processes on CO₂ cycling during, and following, the 1991-92 ENSO event. Data were collected meridionally along four transects, generally between 10°N and 10°S. The first leg (Leg 3) included the 140°E and 125°E transects; the second leg (Leg 4) sampled along 110°E, and the third leg (Leg 5) included stations along 95°E and three short transects extending westward from the Peru coast. Chemical parameters sampled included fCO₂, DIC, TA, pH, TOC, and nutrients. Ancillary measurements of salinity, temperature, and dissolved oxygen (DO) were also taken. Descriptions of sampling methods and data summaries are given in this report.

1.0 INTRODUCTION

Human activity is rapidly changing the trace gas composition of the earth's atmosphere, causing the greenhouse warming effect from excess carbon dioxide (CO₂) along with other trace gas species such as chlorofluorocarbons, methane, and nitrous oxide. These gases play a critical role in controlling the earth's climate because they increase the infrared opacity of the atmosphere, causing the planetary surface to warm. Of all the anthropogenic CO₂ that has ever been produced, only about half remains in the atmosphere; it is the missing CO₂ for which the global ocean is considered to be the dominant sink for the man-made increase.

The equatorial region of the Pacific Ocean (EqPac) is unique because of the huge tongue of cool surface water which is characterized by high concentrations of nutrients and CO₂. Our goal was to investigate the role of equatorial processes on CO₂ cycling during and following the 1991-92 El Niño-Southern Oscillation (ENSO) event, and to better understand the rate at which CO₂ is released by the oceans.

The National Oceanic and Atmospheric Administration's (NOAA) Ocean-Atmosphere Carbon Exchange Study (OACES) Program, in cooperation with the U.S. Joint Global Ocean Flux Study (U.S. JGOFS) Program, the Equatorial Pacific Ocean Climate Study (EPOCS) and Tropical

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Ocean Global Atmosphere (TOGA) Program, participated in a multifaceted oceanographic research cruise

conducted aboard the NOAA Ship *Discoverer* from September 6 to December 8, 1992. The primary objective of this U.S. JGOFS/OACES effort was to determine the relative effects of biological fixation of carbon within equatorial upwelling, followed by vertical flux of that fixed carbon to abyssal depths, and of CO₂ outgassing. The cruise was focused on determining the concentrations of carbon species and describing ocean circulation in the upper ocean over the equatorial Pacific from 95E to 140E. This data report summarizes the carbon species, nutrients, dissolved oxygen, total organic carbon, and salinities from this cruise. The tabulated discrete bottle data are given in Appendix A.

1.1 Cruise Itinerary

The ship departed Hilo, Hawaii on Sept. 6, 1992 and proceeded to the first station at 10E and 140E. A test cast was performed during the transit to check equipment. The cruise track for the first leg (Leg 3) of the cruise started at 10E, 140E and proceeded south along the longitudinal line to 10S; the ship then transited to 10S, 125E, and sampled north along that meridional line to 10E; Leg 3 ended in Manzanillo, Mexico.

The second leg (Leg 4) departed Manzanillo, Mexico on Oct. 12, 1992 and began operations at 10E, 110E. Problems with the electrical generator forced a diversion to San Diego for repairs. Research was resumed at 8E on Oct. 31, and stations were sampled along 110E longitude to 10S; additionally, stations were sampled between 2S and 2N along 95E. The ship ended Leg 4 in Salinas, Ecuador on Nov. 18, 1992.

The third leg (Leg 5) departed Salinas, Ecuador on Nov. 19, 1992 and occupied stations off the coast of Peru along 5S from 81E20W to 82E30W. An additional line of stations was completed between 12E51N, 78E30W to 12E20N, 77E20W, and then between 3E3N, 81E21W to 95E, 14S where stations were occupied along the meridional line to 3N, where a medical evacuation forced cessation of the sampling. The cruise ended in San Diego on Dec. 8, 1992. Station locations and dates are contained in Figure 1 and Table 1.

2.0 SAMPLING AND ANALYTICAL METHODS

2.1 CTD and Hydrographic Operations

AOML's Neil Brown Instrument Systems (NBIS) Mark IIIb CTD #4 and General Oceanics 24-bottle rosette were used to measure pressure, temperature, and conductivity for all casts through station 67 on Leg 4. After station 67, AOML's NBIS Mark IIIb CTD #1 and General Oceanics 12-bottle rosette were employed and two casts were completed at each station in order to similarly sample the water column. CTD data were recorded during the downcast and the upcast, and discrete water samples were collected in 10-L Niskin bottles during the upcast. CTD data passed through an NBIS 1150 deck unit were acquired using AOML CTD acquisition software. A personal computer displayed real-time profiles and wrote the data to hard disk. An audio backup was made to VHS tape. Data files were archived on 5.25" removable hard disk cartridges.

Pre-cruise calibrated, 1-db averaged data files were calibrated and processed at PMEL (McTaggart *et al.*, 1994). To correct for cast-dependent drifts, coefficients of a least squares fit of CTD salinities and bottle salinities to a first order polynomial were computed for groups of stations

Table 1. Station locations and dates of the boreal autumn EqPac 1992 cruise.

Station	Cast	Latitude	Longitude	Date
<i>Leg 3:</i>				
1(test cast)	4	16E 29.79NN	149E 53.57NW	7-Sep-92
2	10	10E 0.38NN	139E 59.45NW	10-Sep-92
3	12	8E 57.67NN	140E 18.19NW	10-Sep-92
4	17	7E 59.98NN	139E 59.95NW	11-Sep-92
5	19	6E 0.28NN	139E 59.97NW	11-Sep-92
6	21	5E 0.39NN	140E 3.33NW	11-Sep-92
6	26	5E 0.2NN	140E 3.41NW	12-Sep-92
7	28	3E 58.3NN	140E 0.39NW	12-Sep-92
8	32	2E 59.35NN	140E 7.21NW	12-Sep-92
9	34	1E 9.64NN	140E 0.31NW	13-Sep-92
10	36	1E 0.01NN	139E 59.83NW	13-Sep-92
11	37	0E 29.67NN	140E 0.13NW	13-Sep-92
12	41	0E 0.16NN	140E 0.04NW	14-Sep-92
13	42	0E 15.04NN	139E 59.37NW	14-Sep-92
14	43	0E 15.0NS	139E 59.76NW	14-Sep-92
15	48	0E 29.73NS	139E 59.92NW	15-Sep-92
16	50	0E 59.41NS	139E 59.92NW	15-Sep-92
17	54	2E 0.56NS	140E 0.92NW	16-Sep-92
18	56	2E 59.88NS	140E 0.1NW	16-Sep-92
19	58	3E 59.62NS	140E 0.15NW	16-Sep-92
20	63	4E 58.36NS	140E 1.43NW	17-Sep-92
21	66	6E 0.13NS	140E 0.07NW	17-Sep-92
22	70	7E 0.04NS	140E 0.16NW	17-Sep-92
23	77	10E 0.09NS	135E 0.43NW	19-Sep-92
24	81	10E 0.05NS	125E 0.03NW	20-Sep-92
25	89	7E 57.6NS	125E 1.69NW	22-Sep-92
26	91	5E 59.81NS	125E 0.13NW	22-Sep-92
27	94	4E 59.99NS	125E 0.09NW	23-Sep-92
28	101	4E 0.11NS	125E 0.0NW	23-Sep-92
29	106	3E 0.0NS	125E 0.12NW	24-Sep-92
30	108	1E 59.98NS	125E 0.03NW	24-Sep-92
31	115	0E 59.9NS	124E 59.33NW	25-Sep-92
32	118	0E 29.88NS	124E 59.66NW	25-Sep-92
33	119	0E 14.93NS	124E 59.53NW	26-Sep-92
34	122	0E 1.35NN	124E 52.66NW	26-Sep-92
35	126	0E 15.33NN	124E 59.34NW	27-Sep-92
36	127	0E 30.79NN	124E 59.98NW	27-Sep-92
37	129	1E 1.47NN	124E 59.48NW	27-Sep-92
38	134	1E 59.95NN	125E 0.13NW	28-Sep-92
39	144	2E 59.86NN	125E 0.26NW	28-Sep-92
40	146	4E 0.09NN	125E 0.06NW	29-Sep-92
41	153	5E 3.12NN	125E 0.9NW	30-Sep-92
42	156	6E 0.07NN	124E 59.9NW	30-Sep-92
43	157	6E 59.85NN	124E 59.46NW	30-Sep-92
44	159	8E 3.45NN	124E 59.77NW	1-Oct-92
45	163	8E 59.82NN	124E 59.91NW	1-Oct-92
46	169	9E 59.28NN	124E 59.36NW	2-Oct-92
47	174	11E 59.37NN	125E 0.44NW	2-Oct-92
48	175	13E 42.92NN	120E 0.09NW	3-Oct-92

Table 1. (continued)

Station	Cast	Latitude	Longitude	Date
<i>Leg 4:</i>				
50	182	10E 1.08NN	109E 56.85NW	17-Oct-92
51	187	8E 0.03NN	110E 0.09NW	31-Oct-92
52	195	5E 59.78NN	109E 59.8NW	1-Nov-92
53	201	4E 58.14NN	109E 54.98NW	1-Nov-92
54	208	3E 59.02NN	109E 59.79NW	2-Nov-92
55	209	2E 59.85NN	110E 0.56NW	2-Nov-92
56	211	2E 6.75NN	110E 6.8NW	2-Nov-92
57	218	0E 59.69NN	110E 0.71NW	3-Nov-92
58	223	0E 31.14NN	110E 0.15NW	3-Nov-92
59	224	0E 15.26NN	109E 59.98NW	4-Nov-92
60	229	0E 11.64NN	110E 5.3NW	4-Nov-92
61	234	0E 0.79NN	110E 0.38NW	4-Nov-92
62	235	0E 15.19NS	110E 0.12NW	5-Nov-92
63	236	0E 30.9NS	110E 0.36NW	5-Nov-92
64	237	1E 0.0NS	109E 59.97NW	6-Nov-92
65	244	2E 5.6NS	109E 54.1NW	6-Nov-92
66	247	2E 59.51NS	110E 1.11NW	7-Nov-92
67	253	3E 59.97NS	109E 58.35NW	8-Nov-92
67	254	4E 0.04NS	109E 58.54NW	8-Nov-92
68	255	4E 59.86NS	110E 2.13NW	8-Nov-92
68	258	4E 59.95NS	110E 1.72NW	8-Nov-92
69	264	6E 0.01NS	110E 0.01NW	8-Nov-92
69	266	5E 59.9NS	110E 0.04NW	9-Nov-92
70	267	8E 0.05NS	109E 59.96NW	9-Nov-92
70	270	7E 59.68NS	110E 0.16NW	9-Nov-92
71	276	10E 0.03NS	110E 0.11NW	10-Nov-92
71	278	9E 59.91NS	109E 59.94NW	10-Nov-92
72	287	2E 0.0NS	95E 0.0NW	13-Nov-92
73	291	0E 0.86NS	95E 3.34NW	14-Nov-92
74	296	1E 57.28NN	94E 9.05NW	15-Nov-92
<i>Leg 5:</i>				
75	302	5E 0.0NS	81E 20.02NW	20-Nov-92
76	303	4E 59.95NS	81E 30.04NW	20-Nov-92
76	306	5E 0.1NS	81E 29.88NW	21-Nov-92
77	307	5E 0.03NS	81E 40.08NW	21-Nov-92
77	308	5E 0.06NS	81E 40.0NW	21-Nov-92
78	309	5E 0.01NS	81E 50.01W	21-Nov-92
78	311	5E 0.07NS	81E 50.09NW	21-Nov-92
79	312	5E 0.02NS	81E 59.99NW	21-Nov-92
79	313	4E 59.98NS	82E 0.05NW	21-Nov-92
80	314	5E 0.02NS	82E 30.12NW	21-Nov-92
80	318	4E 59.95NS	82E 29.88NW	21-Nov-92
81	319	12E 51.0NS	78E 36.92NW	23-Nov-92
81	321	12E 51.0NS	78E 37.02NW	23-Nov-92
82	322	12E 45.24NS	78E 21.29NW	23-Nov-92
82	323	12E 44.93NS	78E 21.03NW	23-Nov-92
83	324	12E 39.02NS	78E 5.9NW	23-Nov-92
83	327	12E 38.94NS	78E 5.83NW	23-Nov-92
84	328	12E 32.0NS	77E 48.99NW	23-Nov-92

Table 1. (continued)

Station	Cast	Latitude	Longitude	Date
<i>Leg 5 (cont.):</i>				
84	332	12E 32.14NS	77E 49.0NW	23-Nov-92
85	333	12E 26.81NS	77E 35.51NW	23-Nov-92
85	337	12E 26.84NS	77E 35.6NW	23-Nov-92
86	338	12E 19.98NS	77E 19.86NW	24-Nov-92
87	340	13E 2.58NS	81E 20.74NW	24-Nov-92
87	344	13E 2.54NS	81E 20.81NW	24-Nov-92
88	345	13E 0.14NS	84E 4.6NW	25-Nov-92
88	347	13E 13.98NS	84E 4.48NW	25-Nov-92
89	348	13E 25.6NS	86E 48.3NW	25-Nov-92
89	352	13E 25.47NS	86E 8.5NW	25-Nov-92
90	353	13E 32.34NS	88E 29.81NW	26-Nov-92
91	354	13E 36.92NS	89E 32.24NW	26-Nov-92
91	356	13E 36.96NS	89E 2.18NW	26-Nov-92
92	357	13E 48.61NS	92E 15.71NW	26-Nov-92
92	361	13E 48.65NS	92E 15.98NW	26-Nov-92
93	362	14E 0.05NS	94E 59.9NW	27-Nov-92
93	364	14E 0.01NS	94E 59.98NW	27-Nov-92
95	366	11E 55.08NS	94E 59.97NW	27-Nov-92
95	369	11E 55.09NS	95E 0.0NW	28-Nov-92
96	370	10E 0.24NS	94E 59.89NW	28-Nov-92
96	372	9E 59.99NS	95E 0.0NW	28-Nov-92
97	373	8E 0.05NS	95E 0.09NW	28-Nov-92
97	377	8E 0.1NS	95E 59.75NW	28-Nov-92
98	378	6E 0.1NS	95E 0.37NW	29-Nov-92
98	380	5E 59.98NS	94E 59.96NW	29-Nov-92
99	381	5E 0.0NS	95E 0.1NW	29-Nov-92
99	383	5E 0.03NS	95E 0.06NW	29-Nov-92
100	388	4E 0.2NS	95E 0.14NW	29-Nov-92
100	390	4E 0.09NS	95E 0.14NW	30-Nov-92
101	391	4E 0.09NS	95E 0.14NW	30-Nov-92
101	393	3E 0.18NS	94E 59.97NW	30-Nov-92
102	395	1E 59.95NS	95E 0.13NW	30-Nov-92
102	399	1E 59.92NS	95E 0.17NW	30-Nov-92
103	401	1E 0.16NS	94E 59.92NW	30-Nov-92
103	403	1E 0.21NS	94E 59.57NW	30-Nov-92
104	405	0E 0.01NN	95E 0.18NW	1-Dec-92
105	410	1E 0.08NN	95E 0.2NW	1-Dec-92
105	414	0E 59.95NN	95E 0.39NW	1-Dec-92
106	416	1E 59.94NN	95E 0.31NW	1-Dec-92
106	418	2E 0.0NN	94E 0.2NW	2-Dec-92
107	423	3E 0.04NN	95E 0.06NW	2-Dec-92

Table 2. Coefficients of least squares fit of CTD and bottle salinities during Legs 3, 4, and 5 of the boreal autumn EqPac 1992 cruise.

Station	Bias	Slope	Std. Dev.	# of Pts.
1B 22	E0.1592176EB01	0.1000271E+01	0.0056	396
23B 48	0.1783609EB01	0.9993343E+00	0.0067	472
49B 67	E0.1083432E+00	0.1003059E+01	0.0042	351
67	E0.2837561E+00	0.1007903E+01	0.0049	21
68B 74	0.9982839EB01	0.9972650E+00	0.0029	71
75B107	0.3461486EB01	0.9990724E+00	0.0023	634

and applied to CTD salinities (Table 2). No additional calibrations were applied to pressure or temperature.

Samples were collected from 10-L PVC Niskin $\text{\textcircled{J}}$ bottles in the following order: dissolved oxygen (DO), discrete fugacity of CO₂ (fCO₂), dissolved inorganic carbon (DIC), pH, total alkalinity (TAlk), C-13/C-12 isotope ratios, nutrients, total organic carbon (TOC), particulate organic carbon (POC), particulate organic nitrogen (PON), and salinities. In addition, underway surface fCO₂ samples were collected on a continuous basis throughout the cruise. This report does not address C-13/C-12, POC, PON or underway fCO₂ measurements.

2.2 Dissolved Oxygen (DO)

DO samples were the first to be collected from 10-L Niskin $\text{\textcircled{J}}$ bottles once the CTD unit was retrieved on deck. Samples were collected in volume-calibrated 150-mL, clear, ground-glass stoppered sample bottles using Tygon $\text{\textcircled{J}}$ tubing; the drawing tube was outfitted with a latex attachment to prevent the Tygon $\text{\textcircled{J}}$ tubing from coming into contact with the stopcock nipple and causing TOC contamination. The sample bottles were rinsed twice and filled from the bottom to minimize bubble entrainment, and overflowed approximately half a volume. 1-mL manganous chloride (600 g MnCl₂-4H₂O in 1 L H₂O) and 1-mL alkaline sodium iodide (320 g NaOH and 600 g NaI in 1 L H₂O) were added to the sample bottles. The top depressions of the bottles were filled with fresh water to prevent intrusion of air, and samples were kept in darkness until analysis.

DO samples were titrated following the technique of Carpenter (1965) and Friederich *et al.* (1984). A computer-controlled automatic pipette was used for titration with photometric endpoint determination. Values are marked as questionable in the data tables when there were high or low photometric endpoints in the titration process due to improper light levels, or there was possible contamination during processing (air bubbles seen in bottle, etc.). The data are reported in the data tables (Appendix A) in $\mu\text{mol/L}$, but are available in the data base in both $\mu\text{mol/L}$, and $\mu\text{mol/kg}$. The density conversion was made using in-situ temperatures and measured salinity.

2.2.1 DO data quality control assessment

The most useful quality control checks with other data sets would compare deep water values. However, the maximum depth of the casts was #1000 db, and variability in DO values cannot be

excluded at 1000 db. The quality of the data was evaluated by examining profiles, contour maps, replicates, property/property plots, and comparisons with other data sets.

For nearly every cast on these cruises, a second Niskin[®] was tripped at the maximal depth. This gave a large set of duplicate samples which was used to assess the combined precision of the analytical technique, the Niskin[®] subsampling technique, and ocean subsampling by the Niskin[®] (Appendix B). Precision is here defined as the average of the relative error between the samples and it is expressed in percent. The relative error is expressed as the absolute difference divided by the mean for two samples or standard deviation divided by the mean for more than two samples.

For Leg 3 the double-trip duplicates were all sampled from 1000 db (41 pairs). The mean difference of duplicate results was 0.40% with 1.22% standard deviation if one pair (Station 45 at 9EN, 125EW) was excluded. These statistics are consistent with the statistics for a set of Niskin[®] subsampling duplicates taken from 13 different Niskin[®] bottles on one cast on Leg 3 (Station 12 at 0E, 140EW) which gave a standard deviation from the mean of 1.14%. On Leg 4, 20 duplicates plus one triplicate were sampled from Niskins[®] tripped at 1000 db. The mean difference was 0.29% with 1.08% standard deviation. For Leg 5, 29 pairs of duplicates were sampled from Niskins[®] tripped at 800 db. The mean difference was 1.65% with 3.92% standard deviation. The overall mean difference for all three legs was 0.78% difference between duplicates with 2.42% standard deviation if one pair (Station 45 at 9EN, 125EW) was excluded.

2.3 Discrete fugacity of CO₂ (fCO₂)

Samples were drawn from 10-L Niskin[®] bottles into 500-mL Pyrex[®] volumetric flasks using Tygon[®] tubing outfitted with a latex attachment to prevent the Tygon[®] tubing from coming into contact with the stopcock nipple. Bottles were rinsed once, and while taking care not to entrain air bubbles, were filled from the bottom until half the bottles= volume overflowed. Five mL of water was then withdrawn with a pipette to create a small expansion volume. A saturated HgCl₂ solution (0.2 mL) was added to the samples as a preservative. The sample bottles were then sealed with a screw cap containing a polyethylene liner and stored in darkness at room temperature for a maximum of 24 hours prior to analysis.

The AOML discrete fCO₂ system is patterned after the design described in Chipman *et al.* (1993) and is discussed in detail in Wanninkhof and Thoning (1993). The major difference between the two systems is that the AOML system uses a Licor[®] (model 6262) non-dispersive infrared analyzer, while the Chipman *et al.* system utilizes a gas chromatograph with a flame ionization detector and a methanizer, which quantitatively converts CO₂ into CH₄ for analysis.

The samples were brought to a temperature of 20.00 ± 0.02EC, using a pre-bath at 19.21EC and a Neslab[®] (model RT-220) controlled temperature bath. In the analyses, two samples are analyzed concurrently; a 60-mL headspace is created in the flasks by replacing the water using a compressed standard gas with a CO₂ mixing ratio close to the anticipated fCO₂ of the water. The headspace is circulated in a closed loop through the infrared analyzer (IR), which measures CO₂ and water vapor levels in the sample cell. The headspaces of the two flasks are equilibrated

simultaneously in channels A and B. While headspace from the flask in channel A goes through the IR analyzer, the headspace of the flask in channel B is recirculated in a closed loop. The sample in the A channel is equilibrated for 17 minutes while the air from the headspace of the flask flows through the IR analyzer. The sample in the B channel is circulated in a closed loop for 10 minutes and through the IR for 8 minutes. An expandable volume, consisting of a balloon, keeps the contents of the flasks at room pressure.

In order to maintain measurement accuracy and precision, a set of six gas standards was run through the system after every four to ten seawater samples. The standards have mixing ratios of 201.4, 352.2, 511.7, 1012.2, 1552.8, and 2019.8 ppm, which bracket the $f\text{CO}_2$ at 20EC ($f\text{CO}_2$, 20) values observed in the water column of the equatorial Pacific. The commercial CO_2 standards (supplied by ScottJ and Air ProductsJ) in Artificial air@ were calibrated against WMO (World Meteorological Organization) standards in real air supplied by Dr. Charles Keeling of Scripps Institution of Oceanography (SIO) with mixing ratios of 204.0, 350.4, 795.0, and 1504 ppm.

The determination of $f\text{CO}_2$ in water from the discrete analyses involves several steps. The mixing ratio and detector response for the standards were normalized for temperature and pressure. The IR voltage output for samples were normalized with regard to pressure and were corrected for the presence of water vapor and converted to a mixing ratio. The mixing ratio in the headspace was converted to fugacity and corrected to fugacity of CO_2 in the water sample prior to equilibration by accounting for change in DIC in water during the equilibration process (for details see Wanninkhof and Thoning, 1993). The change in the $f\text{CO}_2$ of water, ($f\text{CO}_{2w}$), caused by the change in DIC, was calculated using the constraint that TA_{alk} remains constant during exchange of CO_2 gas between the headspace and the water. The calculation is outlined in the appendix of Peng *et al.* (1987).

Precision of the $f\text{CO}_2$ analyses shown in Table 3 were determined in four different ways: from re-analyses of the same water sample; from agreement between surface mixed layer values (where mixed layer is defined as the depth of the surface layer with temperatures within 0.5°C); from duplicates of samples taken from the same NiskinJ bottle; and duplicates taken from the same depth but from different NiskinJ bottles. The precision is defined as the average of the relative

Table 3. Precision of discrete $f\text{CO}_2$ samples taken during Legs 3, 4 and 5 of the boreal autumn EqPac 1992.

	Leg 3		Leg 4		Leg 5	
	precision %	# of replicates	precision %	# of replicates	precision %	# of replicates
Re-analysis	0.42	35	0.12	31	0.17	50
Same depth	1.10	36	0.38	23	0.36	34
Mixed layer	3.21	39	0.77	21	1.45	26
Same NiskinJ	0.99	2	N/A		N/A	

error between the samples and is expressed in percent. The percent relative error is expressed as the absolute difference divided by the mean for two samples, or standard deviation divided by the mean for more than two samples.

2.4 Dissolved Inorganic Carbon (DIC)

Samples were drawn from 10-L Niskin bottles into 500-mL Pyrex bottles using Tygon tubing outfitted with a latex attachment to prevent the Tygon tubing from coming into contact with the stopcock nipple. Bottles were rinsed once and filled from the bottom, overflowing half a volume while taking care not to entrain any bubbles. The tube was pinched off and withdrawn, creating a 5-mL headspace volume. 0.2 mL of saturated HgCl₂ solution was added as a preservative. The sample bottles were sealed with glass stoppers lightly covered with Apiezon-L grease, and were stored at room temperature in the dark for a maximum of 24 hours prior to analysis by coulometric determination.

DIC was analyzed by coulometry, and two analytical set-ups were used simultaneously on the cruise, each consisting of a coulometer (UIC, Inc.) coupled with a SOMMA (Single Operator Multiparameter Metabolic Analyzer) inlet system developed by Ken Johnson (Johnson, 1992; Johnson *et al.*, 1993) of Brookhaven National Laboratory (BNL). AOML-1 was supplied by the group from NOAA/AOML, and PMEL-1 was provided by the group from NOAA/PMEL.

In the coulometric analysis of DIC, all carbonate species (CO₃^{2B} and HCO₃^B) are converted to CO₂ (gas) by addition of excess H⁺ to seawater, and includes the following steps: the 500-mL sample bottle is inserted in a water bath at 20EC and allowed to come to thermal equilibrium; water from the bottle is displaced by pressurization into a calibrated, thermostatted pipette using a headspace gas (511 ppm CO₂ in N₂). Using Ultra-Pure N₂ as the carrier gas, the sample is injected into the reaction vessel in the SOMMA which contains 1-mL 10% H₃PO₄ solution previously stripped of CO₂, and the evolved CO₂ gas from the sample is carried through a condenser and a Mg(ClO₄)₂ column to dry the gas stream, and then through an ORBO-53 tube to remove volatile acids other than CO₂. In the titration cell of the coulometer, CO₂ reacts quantitatively with ethanolamine to form hydroxyethyl carbamic acid which is titrated with OH^B ions electrogenerated by the reduction of H₂O at a platinum cathode. The equivalence point is detected photometrically with thymolphthalein as indicator. The cell solution is blue at the equivalence point of 10.5 pH and colorless at pH 9.3 after the addition of CO₂ in aqueous solutions (Johnson *et al.*, 1985). CO₂ drives down the pH and raises % transmittance. As the acid is titrated, pH increases (hence, the blue color returns) and % transmittance decreases, thus causing the titration current to decrease as the equivalence point is approached and sensed by the optical detector. Therefore, the CO₂ is measured by the quantity of electrons required to reach the equivalence point, calculated by the magnitude of the current and the time of passage.

The coulometers were each calibrated by injecting aliquots of pure CO₂ (99.995%) by means of an 8-port valve outfitted with two sample loops. The loop volumes were calibrated at BNL (Wilke, 1993) prior to, and following, the cruise, and no significant difference was found between the pre- and post-cruise calibrations. All DIC values were corrected for dilution by 0.2 mL of HgCl₂ solution assuming the solution was saturated with atmospheric CO₂ levels and total water volume was 540 mL. The correction factor used was 1.00037. No correction was made for headspace gas exchange with the sample due to the probable variability of fCO₂ at the location of sampling, and the

small magnitude ($<1.0 \mu\text{mol/kg}$) of the correction. The overall accuracy and precision for both the AOML and PMEL instruments combined was determined to be within $\nabla 1.8 \mu\text{mol/kg}$.

The instruments were calibrated at the beginning, middle and end of each coulometer cell solution with a set of the gas loop injections. Calculation of the amount of CO_2 injected was according to the DOE Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water, Ver. 2 (1994). The set of gas loops yielded a mean calibration factor (CF) for the instrument defined as:

The concentration of DIC in the samples was determined according to:

where ACounts is the instrument reading at the end of the analysis, ABlank is the counts/minute determined from blank runs performed at least once for each cell solution, ARun Time is the length of coulometric titration (in minutes), 2.0728×10^4 is the conversion factor from counts to μmol .

The pipette volume was determined by taking aliquots at known temperature of distilled water dispensed from the pipette before, during, and after the cruise and weighing them ashore. No significant volume change was observed for either instrument. The weights with the appropriate densities were used to determine the volume of the pipette. Calculation of pipette volumes, density, and final CO_2 concentration were performed according to procedures outlined in the DOE Handbook (1994).

A Certified Reference Material (CRM) consisting of seawater poisoned with HgCl_2 (Batch 12) prepared by Dr. Andrew Dickson (SIO) was analyzed on both instruments over the duration of the cruise (Table 4). The absolute value was determined by the manometric technique of Dr. Charles Keeling, also of SIO. All DIC data have been corrected to the CRM values on a per instrument/per leg basis; the corrections applied are given in Table 5.

The precision of the DIC measurements was determined in three different ways: analyses of six Niskin bottles all tripped at ~ 1000 db at Station 1 (test cast) yielded a standard deviation of $\nabla 1.7 \mu\text{mol/kg}$; CRM samples (Table 4) analyzed during the cruise show that the standard deviation at the 1σ level were within $\nabla 1.9 \mu\text{mol/kg}$ ($n = 138$); duplicate pairs tripped at the maximal depth throughout the cruise show a mean difference of $0.1 \nabla 2.1 \mu\text{mol/kg}$ ($n = 93$).

Table 4. Certified reference material (Batch 12) analyzed during the boreal autumn EqPac 1992.

	PMEL-1 μmol/kg	AOML-1 μmol/kg
Leg 3:	1984.1 ∓ 1.8, n = 37	1985.6 ∓ 0.8, n = 21
Leg 4:	1986.0 ∓ 1.9, n = 20	1985.1 ∓ 1.2, n = 22
Leg 5:	1983.9 ∓ 0.9, n = 19	1986.3 ∓ 0.3, n = 19

Manometrically derived DIC = 1984.26 ∓ 0.73 μmol/kg (n = 7). Standard deviations are given at the 1σ level.

Table 5. Corrections applied to DIC data during the boreal autumn EqPac 1992 cruise.

	PMEL-1 μmol/kg	AOML-1 μmol/kg
Leg 3:	+0.2	B1.3
Leg 4:	B1.7	B0.9
Leg 5:	+0.4	B2.0

2.5 pH

Sample cells (10-cm pathlength spectrophotometric cells, 30-cm³ volume) were filled directly from the Niskin bottle using a 20-cm length of Tygon tubing outfitted with a latex attachment to prevent the Tygon from coming into contact with the stopcock nipple; a flushing volume of approximately 300 mL was used. Care was taken to eliminate bubbles from the sampling system, and the sample cell was sealed with PTFE caps while ensuring that there was no head space.

All spectrophotometric pH measurements were made using the indicator m-Cresol Purple. Spectrophotometric cells were warmed to 25°C in a twelve-chambered thermostated aluminum block and subsequently cleaned and placed in the thermostated sample compartment of the spectrophotometer. Absorbance measurements were made at three wavelengths: a non-absorbing wavelength (730 nm) and wavelengths corresponding to the absorbance maxima of the alkaline (I^{2B}, 578 nm) and acidic (HI^B, 434 nm) forms of the indicator. Subsequently, one of the cell caps was removed and 0.08 cm³ of concentrated indicator (2 μmol/cm³) was injected into the cell. The cell was capped, rapidly mixed and returned to the thermostated cell. Absorbance measurements were again made at 730 nm, 578 nm and 434 nm. Sample pH was then calculated using the equations and procedures of Clayton and Byrne (1993). The A_{total} pH scale is used, and pH_T is reported in mol/kg of seawater.

2.6 Total Alkalinity (TAlk)

Samples were drawn from 10-L Niskin $\text{\textcircled{J}}$ bottles into 500-mL Pyrex $\text{\textcircled{J}}$ bottles using Tygon $\text{\textcircled{J}}$ tubing outfitted with a latex attachment to prevent the Tygon $\text{\textcircled{J}}$ tubing from coming into contact with the stopcock nipple. Bottles were rinsed once and filled from the bottom, overflowing half a volume while taking care not to entrain any bubbles. The tube was pinched off and withdrawn, creating a 5-mL headspace volume. The sample bottles were sealed with glass stoppers, and were stored at room temperature in the dark for a maximum of 6 hours prior to analysis by potentiometric determination.

The TAlk titration system was similar to the one used in previous studies (Thurmond and Millero, 1982; Bradshaw and Brewer, 1988) and consisted of a Metrohm 665 Dosimat $\text{\textcircled{J}}$ titrator and an Orion 720A pH meter operated by a personal computer. Both the acid titrant and the seawater sample were maintained at 25EC with a Neslab $\text{\textcircled{J}}$ temperature bath. The plastic jacketed cells (volume $\sim 200\text{ cm}^3$) were patterned after an earlier design of Bradshaw and Brewer (1988) except a larger volume was used to increase the precision. The cell had zero dead volume valves to increase the reproducibility of the cell volume. A GW-Basic $\text{\textcircled{J}}$ program was used to control the titrant addition and read the emf of the electrodes. The titration was made by adding HCl to seawater past the carbonic acid end point. A typical titration records the emf reading after it becomes stable (0.09 mV) and adds enough acid to change the voltage by a pre-assigned increment (13 mV). The electrodes used to measure emf consisted of a ROSS $\text{\textcircled{J}}$ glass pH electrode and an Orion $\text{\textcircled{J}}$ double junction Ag/AgCl reference electrode.

The HCl acid solutions (20 L) were made, standardized, and stored in 500-mL glass bottles prior to the cruise. The 0.25 M HCl solutions were made with 1 M Mallinckrodt $\text{\textcircled{J}}$ standard solutions in 0.45 M NaCl to yield an ionic strength equivalent to that of average seawater (0.7 M). The acid was standardized by titrating weighed amounts of Na_2CO_3 and TRIS dissolved in 0.7 M NaCl solutions. The blanks in the 0.7 M NaCl solutions were determined by coulometry and by titrations of the NaCl solutions with and without added Na_2CO_3 and TRIS. The blanks of the titrations of TRIS were determined by extrapolation to zero added salt (Goyet and Hacker, 1992).

The alkalinity blanks in the NaCl were approximately $14 \pm 1\ \mu\text{mol}$. Cell volumes were determined in the laboratory by weighing the cells filled with degassed Millipore water. The density of water at the temperature of the measurements (25EC) was calculated from the international equation of state of seawater (Millero and Poisson, 1981). The nominal volumes of all the cells were about 200 cm^3 and the values were determined to 0.03 cm^3 .

The NaCl, Na_2CO_3 and NaHCO_3 salts used to make up the solutions were Baker Analyzed $\text{\textcircled{J}}$ reagent grade. Details on preparation and calibration of the seawater buffers are given in Dickson (1993) and Millero (1993). Approximately 20 L of standard carbonate solutions in 0.7 M NaCl were prepared for the calibrations of the acids. The solutions were equilibrated with air to provide an alkalinity and nearly constant DIC standard. The DIC in the blanks and carbonate solutions was measured daily using a coulometer (see Section 2.4). The coulometer was calibrated using CO_2 gas loops and monitored with Batch #12 CRM.

The volume of HCl delivered to the cell is traditionally assumed to have small uncertainties (Dickson, 1981) due to the digital output of the titrator. Calibrations with water at 25°C of the Dosimat[®] burettes indicate that the systems deliver 3 cm³, a typical value for a titration of seawater, to a precision of 0.0004 cm³. This uncertainty results in an error of 0.4 μmol kg⁻¹ in TAlk. The accuracy of the volume of acid delivered by the Dosimat[®], however, was ten times poorer (0.004 cm³) than the precision. Since the titration systems were calibrated using standard solutions, this error in accuracy of volume delivery will be partially cancelled and included in the value assigned to the concentration of HCl and the volume of the cell.

2.7 Nutrients

Nutrient samples were collected from 10-L Niskin[®] bottles in aged 60-mL linear polyethylene bottles after three complete seawater rinses, and stored in the dark at 4°C until analysis was completed (within 24 hours of sample collection). Concentrations of dissolved nitrite (NO₂⁻), dissolved nitrate (NO₃⁻), dissolved phosphate (HPO₄²⁻) and silicate (H₄SiO₄) were determined using an Alpkem[®] Rapid Flow Analyzer[®] (RFA/2[®]) Auto-Analyzer aboard ship. The water used for the preparation of standards, determination of blank and wash between samples was filtered Gulf Stream seawater obtained from the surface of the Strait of Florida. Analytical temperature was assumed to be 25 ± 1°C. The data are reported in the data tables (Appendix A) as μmol/L, but are available in the data base in both μmol/L and μmol/kg. The density conversion was made using the aforementioned analytical temperature and measured salinity.

2.7.1 Nitrite and nitrate

The automated colorimetric procedures and methodologies used in the analysis of nitrite and nitrate are similar to those described by Armstrong *et al.* (1967), with modifications described in Atlas *et al.* (1971). Standardizations were performed prior to each sample run with working solutions prepared aboard ship from pre-weighed Baker Analyzed[®] reagent grade standards. Nitrite (NO₂⁻) was determined by diazotization with sulfanilamide and coupling with N-(1-naphthyl) ethylenediamine dihydrochloride to form an azo dye. The color produced is proportional to the nitrite concentration. Samples for nitrate (NO₃⁻) analysis were passed through copperized cadmium in the form of an Open Tubular Cadmium Reactor (OTCR) coil, which reduced nitrate to nitrite; the resulting nitrite concentration was then determined as described above. The detection limits for nitrite and nitrate were 0.1 μmol/L and 0.4 μmol/L, respectively. The standard deviation of the analyses of samples from two Niskin[®] bottles at 1000 db were used to estimate the overall precision obtained by the sampling and analytical procedures. The percent relative error of nitrate analysis for these samples was 0.38% ± 0.37% (n = 80).

2.7.2 Phosphate

The analytical procedures and methodologies used in the analysis of phosphate are similar to those described by Armstrong *et al.* (1967), with modifications described in Grasshoff *et al.* (1983). In this method, orthophosphate in the samples was determined by reacting with molybdenum (VI) and antimony (III) in an acidic medium to form an antimonyphospho-molybdate complex. This complex was subsequently reduced with ascorbic acid to form a blue complex and the absorbance was measured at 880 nm by a filter photometer in RFA/2J system. The method detection limit was 0.08 $\mu\text{mol/L}$. The percent relative error of phosphate analysis for samples from two NiskinJ bottles at 1000 db was 0.92% \forall 0.77% (n = 76).

2.7.3 Silicate

The analytical procedures and methodologies used in the analysis of silicate are essentially similar to those described by Armstrong *et al.* (1967), with modifications described in Atlas *et al.* (1971). In this modified method, β -molybdosilicic acid was formed by reaction of the silicate contained in the sample with molybdate in an acidic solution. The β -molybdosilicic acid was then reduced by stannous chloride to form molybdenum blue. The absorbance of the molybdenum blue, measured at 660 nm, was linearly proportional to the concentration of silicate in the sample, with a detection limit of 0.4 $\mu\text{mol/L}$. The percent relative error of silicate analysis for samples from two NiskinJ bottles at 1000 db was 1.41% \forall 1.24% (n = 72).

2.8 Total Organic Carbon (TOC)

All samples for total organic carbon (TOC) analysis were collected using the 10L-NiskinJ bottles on a 12- or 24-bottle CTD-rosette. The NiskinJ bottles used red silicone rubber o-rings and nylon coated stainless steel springs; stopcocks were polyethylene.

A strict sample drawing order was followed. Samples for DO, $f\text{CO}_2$, DIC, and pH were drawn first using sample drawing tubes with silicone rubber or surgical rubber connectors. At no time was TygonJ tubing used in direct contact with the stopcock nipple prior to drawing the TOC samples, nor was the vial allowed to come into contact with the stopcock nipple. 30-mL samples were drawn into 40-mL PyrexJ glass vials. The vials were rinsed prior to filling three times with sample and at no time was the vial allowed to come into contact with the NiskinJ stopcock nipple. Samples were tightly capped with teflon lined screw-caps and kept under cover to prevent excessive warming while on deck.

Immediately following collection, the samples were returned to the shipboard lab and acidified with 160 μL of 50% (w/w) H_3PO_4 . Samples were NOT filtered. The samples were stored at 4EC until ready to be shipped home. At that time they were wrapped as flats of 100 vials in bubble wrap, transferred to a cooler filled with frozen Ablue® ice, then hand-carried to the airport and shipped home as excess baggage. All samples were in the lab refrigerator within 48 hours of shipping.

Samples were analyzed by the high-temperature combustion/discrete injection (HTC/DI) technique (Peltzer and Brewer, 1993) using a custom built analyzer. Immediately prior to analysis the

samples were sparged with CO₂-free oxygen at 500 mL/min for 6B7 minutes. Each sample was injected in triplicate into a third-generation HTC/DI analyzer consisting of a two-stage combustion system. The combustion tube contained 5% Pt on alumina catalyst (Dimatec, Essen, Germany) at 800EC in the upper catalyst zone, and copper oxide and SulfixJ (Wako Chemical Corp., Richmond, VA) at 600EC in the lower zone. Oxygen was used as a carrier gas. The gas stream passes through a AgNO₃/H₃PO₄ bubbler, a U-tube cold trap at 1B2EC, a Mg(ClO₄)₂ drying tube and two particle filters (0.1 μm and 0.01 μm, Balston Inc., Lexington, MA) before entering a LiCor Model 6252 NDIR CO₂ analyzer. The output from the CO₂ detector is continuously monitored and recorded using TurboChromJ 3 software operating on a 386-PC in a Windows environment. All peaks were visually checked for proper baseline integration and appropriate peak shape. Those not passing were either manually re-integrated or rejected. If only one peak of the three was acceptable, the sample run was rejected and a new run with three more injections from the same sample was made.

Stringent quality control/quality assurance protocols were followed. Peak areas were converted to organic carbon concentrations by first correcting for the instrument blank, measured with carbon-free distilled water (CFDW), then dividing the result by the instrument response factor determined with organic compound standards (glucose, KHP or glucoseamine) in seawater. The instrument response factor was measured twice daily (at the beginning and end of the day=s runs using high and low TOC standards) and the instrument blank was repeatedly measured throughout the day, typically after every four to six samples. While the instrument blank exhibited a generally decreasing value throughout the lifetime of each furnace tube, the instrument response factor varied less than ∇5% of the mean value over the course of the analysis period and several furnace tube lifetimes.

The CFDW used to measure the instrument blank was obtained from a Milli-QJ water purification system (Millipore, Bedford, MA). This water was consistently found to have the lowest total blank of all the CFDWs tested in multiple direct, head-to-head comparisons. Consequently, it was assigned a residual TOC concentration of 0.0 μmol C and no back correction of the measured TOC values was required. It should be noted that even though this lot of CFDW gave the lowest total blanks, this fact does not guarantee that it did not contain some residual carbon. If at some future date it can be shown that this CFDW did contain some amount of TOC, then the values reported here would need to be revised upwards by this amount. However, such a correction could not exceed the measured total blanks, which were on the order of 6B8 μmol C/L.

TOC values are reported as μmol C/kilogram seawater (μmol/kg). The measured concentration (μmol/L) is converted to μmol/kg by dividing by the density of the sample at the time of the analysis. Sample density is calculated from the measured salinity and lab temperature using the international equation of state of seawater (Millero and Poisson, 1981). The bottle salinity was used whenever available, otherwise the corresponding CTD salinity measured on the downcast was used. For sample temperature, the measured lab temperature at the time of analysis was used.

2.9 Salinity

Salinity samples were collected in 125-mL amber glass bottles directly from the rosette, taking care not to touch the petcock. Bottles were rinsed twice and overflowed one half volume; new caps were used for each sample.

Bottle salinities were measured using a Guildline J 8400 Autosal and #114 standard seawater in a temperature-controlled van. Conductivity ratios were converted to salinities conforming to the PSS78 standard. If there was no bottle salinity available for a given sample position, the CTD value was used in calculations requiring a salinity measurement.

3.0 DATA TABLES

A complete listing of the CTD data is available through NOAA (McTaggart *et al.*, 1994). Discrete data are reported at all observed depths (Appendix A). Where no data is available, a null value is inserted. A quality control column is located next to most of the observed parameters; quality control flags follow the WHP Data Reporting Requirements (WOCE Operations Manual, 1991), and are listed in Table 6. In addition, Table 7 displays unique quality control flags for fCO₂. Sigma-theta ($\sigma\theta$) and potential temperature (θ) values listed in the tables were calculated using standard UNESCO algorithms (Fofonoff and Millard, 1983). Input parameters include salinities and in-situ temperatures from the CTD. Header information at the top of each page includes an operation number consisting of year, Julian date, and GMT at time-at-depth. The Sample ID listed in the data tables consists of the cast number followed by the 2 digit Niskin J rosette position. Due to the loss

Table 6. WOCE data quality flag definitions.

2	Acceptable measurement
3	Questionable measurement
4	Bad measurement
9	Sample not drawn for measurement

Table 7. Unique quality control flag definitions for fCO₂.

Fugacity of CO ₂	
A	No DIC available for calculation
B	No sigma theta available for calculation
D	Estimated DIC used in calculation
E	Estimated sigma theta used in calculation

of the 24-position rosette during Leg 4, and the subsequent requirement to take two 12-position rosette casts per station to maintain our sampling density, those respective stations are contained in

two separate data tables indicated by different cast numbers within Appendix A. To obtain the data base by remote access, please see page iii of this report.

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APPENDIX A
TABULATED DISCRETE BOTTLE DATA

APPENDIX B
DISSOLVED OXYGEN DUPLICATES

Appendix B: Dissolved oxygen duplicates of the boreal autumn EqPac 1992 cruise.

Date	Latitude (EN)	Longitude (EW)	Sta #	Pressure (db)	O ₂ (μmol/L)	% deviation from 1st
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Samples collected from 13 separate Niskin J bottles on same cast

LEG 3:

9/16/92	0	140	12	1000	86.2	
9/16/92	0	140	12	1000	82.8	
9/16/92	0	140	12	1000	83.9	
9/16/92	0	140	12	1000	83.1	
9/16/92	0	140	12	1000	82.9	
9/16/92	0	140	12	1000	83.3	
9/16/92	0	140	12	1000	82.7	
9/16/92	0	140	12	1000	83.0	
9/16/92	0	140	12	1000	83.2	
9/16/92	0	140	12	1000	83.5	
9/16/92	0	140	12	1000	82.7	
9/16/92	0	140	12	1000	83.0	
9/16/92	0	140	12	1000	82.5	
					83.3	Mean of 13
					0.9	Std. Dev.
					1.1	% Rel. Error

Double-trip Duplicates

LEG 3:

9/12/92	9	140	3	1000	34.0	
9/12/92		140	3	1000	34.4	B1.18
9/12/92	8	140	4	1000	37.4	
9/12/92		140	4	1000	36.5	2.41
9/13/92	6	140	5	1000	50.5	
9/13/92		140	5	1000	50.5	0.00
9/13/92	5	140	6	1000	56.9	
9/13/92		140	6	1000	56.3	1.05
9/13/92	4	140	7	1000	52.5	
9/13/92		140	7	1000	52.3	0.38
9/14/92	3	140	8	1000	69.4	
9/14/92		140	8	1000	69.6	B0.29
9/14/92	2	140	9	1000	74.3	
9/14/92		140	9	1000	74.2	0.13
9/14/92	1	140	10	1000	84.7	
9/14/92		140	10	1000	84.4	0.35
9/15/92	0.50	140	11	1000	84.1	
9/15/92		140	11	1000	83.2	1.07
9/15/92	0	140	12	1000	86.9	
9/15/92		140	12	1000	83.0	4.49
9/15/92	0.25	140	13	1000	83.9	
9/15/92		140	13	1000	83.1	0.95
9/16/92	B0.50	140	15	1000	85.7	
9/16/92		140	15	1000	86.9	B1.40
9/16/92	B1	140	16	1000	93.6	

Appendix B: Dissolved oxygen duplicates. (continued)

Date	Latitude	Longitude	Sta #	Pressure	O ₂	% deviation from 1st
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	(EN)	(EW)		(db)	($\mu\text{mol/L}$)	
LEG 3 (continued):						
9/16/92		140	16	1000	92.9	0.75
9/17/92	B2	140	17	1000	90.5	
9/17/92		140	17	1000	89.6	0.99
9/17/92	B3	140	18	1000	91.3	
9/17/92		140	18	1000	91.4	B0.11
9/18/92	B4	140	19	1000	99.1	
9/18/92		140	19	1000	98.6	0.50
9/19/92	B5	140	20	1000	92.7	
9/19/92		140	20	1000	92.2	0.54
9/21/92	B6	140	21	1000	90.7	
9/21/92		140	21	1000	90.5	0.22
9/21/92	B7	140	22	1000	100.0	
9/21/92		140	22	800	98.5	1.50
9/23/92	B10	140	23	1000	90.4	
9/23/92		125	23	1000	90.3	0.11
9/23/92	B10	125	24	1000	78.7	
9/23/92		125	24	1000	78.7	0.00
9/23/92	B7	125	25	1000	91.5	
9/23/92		125	25	1000	91.7	B0.22
9/24/92	B6	125	26	1000	88.4	
9/24/92		125	26	1000	89.7	B1.47
9/25/92	B5	125	27	1000	92.2	
9/25/92		125	27	800	91.7	0.54
9/25/92	B4	125	28	1000	94.9	
9/25/92		125	28	1000	94.6	0.32
9/26/92	B3	125	29	1000	88.0	
9/26/92		125	29	1000	87.7	0.34
9/26/92	B2	125	30	1000	87.5	
9/26/92		125	30	800	87.6	B0.11
9/27/92	B1	125	31	1000	86.0	
9/27/92		125	31	1000	86.1	B0.12
9/27/92	B 0.50	125	32	1000	84.0	
9/27/92		125	32	1000	83.6	0.48
9/27/92	B 0.25	125	33	1000	84.5	
9/27/92		125	33	1000	84.2	0.36
9/28/92	0	125	34	1000	84.6	
9/28/92		125	34	1000	84.4	0.24
9/28/92	0.25	125	35	1000	80.7	
9/28/92		125	35	1000	81.9	B1.49
9/29/92	0.50	125	36	1000	81.8	
9/29/92		125	36	1000	81.4	0.49
9/29/92	1	125	37	1000	79.2	
9/29/92		125	37	1000	78.9	0.38
9/30/92	2	125	38	1000	73.7	
9/30/92		125	38	1000	73.3	0.54
10/1/92	3	125	39	1000	74.1	
10/1/92		125	39	1000	74.3	B0.27
10/1/92	4	125	40	1000	63.9	
10/1/92		125	40	1000	64.9	B1.56

Appendix B: Dissolved oxygen duplicates. (continued)

Date	Latitude (EN)	Longitude (EW)	Sta #	Pressure (db)	O ₂ ($\mu\text{mol/L}$)	% deviation from 1st
LEG 3 (continued):						

10/1/92	5	125	41	1000	54.8	
10/1/92		125	41	800	54.6	0.36
10/5/92	6	125	42	1000	55.5	
10/5/92		125	42	1000	56.0	B0.90
10/5/92	8	125	44	1000	41.3	
10/5/92		125	44	800	39.7	3.87
10/6/92	9	125	45	1000	37.5	
10/6/92		125	45	1000	15.1	59.73
10/6/92	10	125	46	1000	42.5	
10/6/92		125	46	1000	41.6	2.12
						1.81
						9.23
						Mean % deviation
						Std. Dev. %

LEG 4:

10/29/92	10	110	50	1000	30.5	
10/29/92		110		1000	30.7	B0.66
11/1/92	8	110	51	1000	35.1	
11/1/92		110		1000	35.1	0.00
11/2/92	6	110	52	1000	48.8	
11/2/92		110		1000	49.2	B0.82
11/2/92	5	110	53	1000	56.3	
11/2/92		110		1000	55.4	1.60
11/3/92	4	110	54	1000	54.2	
11/3/92		110		1000	55.6	B2.58
11/3/92	3	110	55	1000	70.5	
11/3/92		110		1000	70.3	0.28
11/4/92	1	110	57	1000	76.3	
11/4/92		110		1000	75.7	0.79
11/4/92	0.5	110	58	1000	82.7	
11/4/92		110		1000	82.7	0.00
11/5/92	0.25	110	59	1000	84.0	
11/5/92		110		1000	83.6	0.48
11/5/92	0.18	110	60	1000	83.4	
11/5/92		110		1000	82.6	0.96
11/6/92	0	110	61	1000	80.5	
11/6/92		110		1000	80.5	0.00
11/7/92	B0.25	110	62	1000	84.8	
11/7/92		110		1000	83.4	1.65
11/8/92	B0.5	110	63	1000	86.4	
11/8/92		110		1000	85.9	0.58
11/8/92	B1	110	64	1000	84.9	
11/8/92		110		1000	84.4	0.59
11/8/92	B2	110	65	1000	75.7	
11/8/92		110		1000	75.6	0.13
11/8/92		110		1000	76.0	B0.40
11/9/92	B3	110	66	1000	92.7	
11/9/92		110		1000	93.0	B0.32
11/11/92	B5	110	68	1000	97.7	
11/11/92		110		1000	96.5	1.23

Appendix B: Dissolved oxygen duplicates. (continued)

Date	Latitude (EN)	Longitude (EW)	Sta #	Pressure (db)	O ₂ (μmol/L)	% deviation from 1st
LEG 4 (continued):						
11/12/92	B6	110	69	1000	88.1	
11/12/92		110		1000	87.2	1.02

11/12/92	B8	110	70	1000	76.0		
11/12/92		110		1000	77.1	B1.45	
11/14/92	B10	110	71	1000	73.8		
11/14/92		110		1000	72.3	2.03	
11/15/92	B2	110	72	1000	70.7		
11/15/92		110	72	1000	69.8	1.27	
						0.29	Mean % deviation
						1.08	Std. Dev. %

LEG 5:

11/22/92	B5	82	77	800	35.1		
11/22/92		82	77	800	34.0	3.13	
11/22/92	B5	82	78	800	33.1		
11/22/92		82	78	800	32.9	0.60	
11/22/92	B5	82	79	800	31.5		
11/22/92		82	79	800	31.6	B0.32	
11/22/92	B5	82	80	800	42.9		
11/23/92		82	80	800	42.2	1.63	
11/23/92	B13	78	78	800	24.0		
11/23/92		78	81	800	22.9	4.58	
11/24/92	B13	78	82	800	30.6		
11/24/92		78	82	800	30.0	1.96	
11/24/92	B13	78	83	800	27.3		
11/24/92		78	83	800	26.7	2.20	
11/25/92	B12	78	84	800	31.1		
11/25/92		78	84	800	30.5	1.93	
11/25/92	B12	78	85	800	5.9		
11/25/92		78	85	800	4.9	16.95	
11/26/92	B13	81	87	800	30.3		
11/26/92		81	87	800	30.1	0.66	
11/27/92	B13	84	88	800	28.9		
11/27/92		84	88	800	28.9	0.00	
11/27/92	B13	86	89	800	36.9		
11/27/92		86	89	800	36.3	1.63	
11/28/92	B13	89	91	800	34.3		
11/28/92		89	91	800	33.4	2.62	
11/28/92	B14	92	92	800	34.6		
11/28/92		92	92	800	34.2	1.16	
11/28/92	B14	95	93	800	40.4		
11/28/92		95	93	800	39.4	2.48	
11/29/92	B12	95	95	800	50.5		
11/29/92		95	95	800	50.6	B0.20	
11/29/92	B10	95	96	800	31.5		
11/29/92		95	96	800	30.4	3.49	
11/29/92	B8	95	97	800	40.7		
11/29/92		95	97	800	37.4	8.11	
11/30/92	B6	95	98	800	44.1		

Appendix B: Dissolved oxygen duplicates. (continued)

Date	Latitude (EN)	Longitude (EW)	Sta #	Pressure (db)	O ₂ (μmol/L)	% deviation from 1st
LEG 5 (continued):						
11/30/92		95	98	800	47.3	B7.26
11/30/92	B5	95	99	800	71.5	
11/30/92		95	99	800	71.4	0.14
12/1/92	B4	95	100	800	62.7	

12/1/92		95	100	800	62.6	0.16	
12/1/92	B3	95	101	800	61.0		
12/1/92		95	101	800	62.1	B1.80	
12/1/92	B2	95	102	800	65.2		
12/1/92		95	102	800	65.0	0.31	
12/2/92	B1	95	103	800	68.1		
12/2/92		95	103	800	68.1	0.00	
12/2/92	0	95	104	800	49.8		
12/2/92		95	104	800	50.0	B0.40	
12/3/92	1	95	105	800	52.1		
12/3/92		95	105	800	52.3	B0.38	
12/4/92	2	95	106	800	55.1		
12/4/92		95	106	800	54.7	0.73	
12/4/92	3	95	107	800	39.6		
12/4/92		95	107	800	38.8	2.02	
						1.65	Mean % deviation
						3.92	Std. Dev. %
